In this thesis, the three-phase AC-DC current injection hybrid (series-parallel) resonant converter (CIHRC) is proposed to achieve a high power factor by injecting high-frequency currents into the three-phase diode bridge rectifier, producing a high frequency modulation signal with only two soft-switched active devices. The hybrid configuration resonant converter has the desirable characteristics of both series and parallel configurations. As such, the resonant current dependency problem of the typical series configuration circuit topology can be overcome, allowing the control of the output voltage at no-load or small load conditions. With an appropriate design of hybrid resonant circuit and a suitable switching frequency selection, the devices are capable to operate under virtually lossless zero voltage switching (ZVS) conditions allowing reduction in the size of inductive and magnetic components with high frequency operation. The early stage of the research work involved the derivation of detailed description of the steady-state analysis and characteristics of the proposed CIHRC. The test-rig of 1 kW operating at 20 kHz is developed and tested to be in good agreement with the prediction and simulation results. Next, the small-signal model is developed to design the compensator for the output voltage regulation, in which the derivation of a small-signal model is done by considering the converter to consist of two stages; the line-frequency rectifier and high-frequency resonant circuit. The analysis of line-frequency of the three-phase PWM AC-DC converter is based on the standard method. The resulting circuit equations that are expressed in state-space form are then averaged to remove the ripple. The direct and quadrature (d-q) transformation method is adopted to eliminate the time variance in the equations. In order to model the high-frequency resonant stage, the fundamental frequency methods are adopted. To match the line frequency equations of the three-phase PWM AC-DC converter with the high-frequency resonant stage equations, the power balanced relationship for the DC link methods are employed. Then, by considering small perturbations in all variables, the resulting non-linear model is linearised. The small-signal model is used to design the closed loop controller for the proposed three-phase AC-DC CIHRC. Such closed loop controller of the converter is designed based on the classical techniques of linear network and control theory. In addition, the compensator for the output voltage regulation is designed based on the open-loop control-to-output frequency response, the location of poles and also the trade-off between reducing the output voltage ripple and maintaining the high quality input line current. Design of this controller is verified under small signal change in the load, which is implemented by increasing and decreasing the parameters of the load resistor. With the successful application of the small-signal model in the closed-loop control, the output voltage regulation of the CIHRC is achieved. The proposed converter is further modified to operate wirelessly to provide wireless power transfer feature as an example of one of the salient application of CIHRC. High power transfer efficiency of 92% is obtained showing the feasibility of the converter implementation in the wireless power transfer application whilst maintaining high input power factor. An experimental test-rig is constructed to verify the operation of the proposed system.

The ethanol sensor device fabrication was carried out using undoped zinc oxide nanorod (ZnO NR) arrays, tin doped zinc oxide nanorod (Sn:ZnO NR) arrays and novel nanostructured tin doped zinc oxide/ tin oxide nanorod (Sn: ZnO/SnO2 NR) arrays film. The sensor consists of a thin film nanostructured deposited on the novel seed layer magnesium-aluminium co-doped zinc oxide (MAZO) coated glass using solution immersion technique. The thin film nanostructures were investigated using X-ray diffraction analysis, energy-dispersive X-ray spectroscopy, field emission scanning electron microscopy, atomic force microscopy, photoluminescence spectrometer, ultraviolet-visible-near-infrared spectrometry, thickness profilometry and two-probe current-voltage measurement system. The sensor performance was analysed based on the change in electrical conductivity upon gas adsorption when ethanol gas was exposed to nanorod arrays film that act as sensing materials. The growth of ZnO NR arrays film was influenced by many factors. In this study, some parameters have been done for ethanol sensor application such as doping process (undoped, single doped and co-doped ZnO seed layer), the variation of coating seed layers (one to nine coating layers), the effect of ZnO NR arrays growth on variation coating layers (one to nine coating layers), the effect of ZnO NR arrays growth at different immersion time (15-90 min), the effect of doping process for ZnO NR arrays (undoped and Sn doped) and the effect of pH of SnO2 solution to the growth of Sn:ZnO/SnO2 NR arrays. The conductometric sensor system was set up to study the sensing sensitivity, response and recovery time and selectivity properties towards ethanol gas. The sensor response for Sn:ZnO/SnO2 NR arrays was 20. It was observed that the Sn:ZnO/SnO2 NR arrays film showed the highest response to the presence of ethanol gas compared ZnO and Sn: ZnO NR arrays. The Sn:ZnO/SnO2 NR arrays showed the shorter of response and recovery time which was around 81 and 63 s, respectively. The sensitivity of Sn:ZnO/SnO2 NR arrays prepared at pH 5.5 of SnO2 solution was increased from 2.4 to 5.2 with an increase of ethanol concentration range 60 to 300 ppm. The Sn:ZnO/SnO2 NR arrays prepared at pH 5.5 of SnO2 solution also showed the increasing of sensing sensitivity value range 2.5 to 8.0 when the working temperature is increased from 60 to 140°C. It also was observed that the Sn:ZnO/SnO2 NR arrays have good selectivity properties towards ethanol vapor as compared to acetone and propanol vapor.